S01P1374

FIG. 1

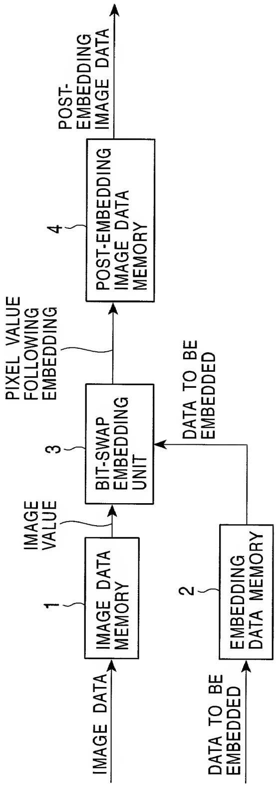


FIG. 2

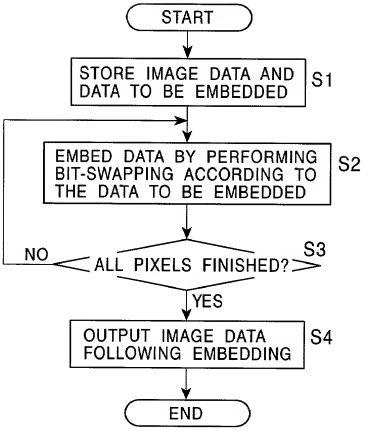

START
STORE IMAGE DATA AND DATA TO BE EMBEDDED
S1
EMBED DATA BY PERFORMING BIT-SWAPPING ACCORDING TO THE DATA TO BE EMBEDDED
S2
ALL PIXELS FINISHED?
S3
NO
YES
OUTPUT IMAGE DATA FOLLOWING EMBEDDING
S4
END

FIG. 3

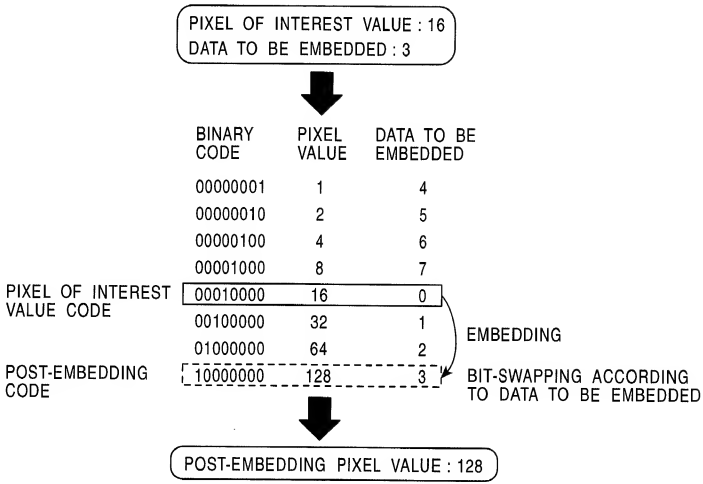

PIXEL OF INTEREST VALUE : 16
DATA TO BE EMBEDDED : 3
BINARY CODE
PIXEL VALUE
DATA TO BE EMBEDDED
00000001 1 4
00000010 2 5
00000100 4 6
00001000 8 7
PIXEL OF INTEREST VALUE CODE
00010000 16 0
00100000 32 1
01000000 64 2
POST-EMBEDDING CODE
10000000 128 3
EMBEDDING
BIT-SWAPPING ACCORDING TO DATA TO BE EMBEDDED
POST-EMBEDDING PIXEL VALUE : 128

FIG. 4

NUMBER OF "0" BITS	NUMBER OF "1" BITS	NUMBER OF PATTERNS (NUMBER OF POSSIBLE COMBINATIONS)	DATA TO BE EMBEDDED (NUMBER OF POSSIBLE COMBINATIONS)	AMOUNT OF INFORMATION (BITS)
0	8	1	0	0.0
1	7	8	8	3.0
2	6	28	28	4.8
3	5	56	56	5.8
4	4	70	70	6.1
5	3	56	56	5.8
6	2	28	28	4.8
7	1	8	8	3.0
8	0	1	0	0.0

FIG. 5

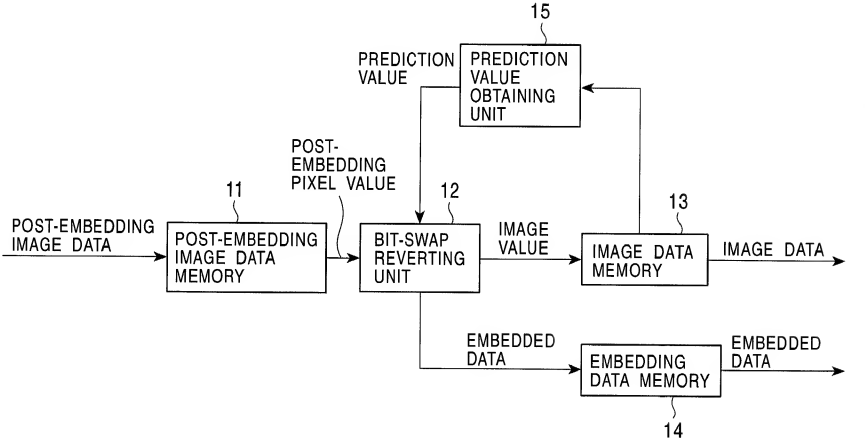


FIG. 6

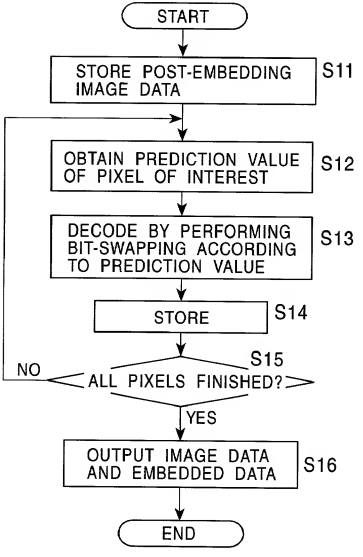

START
STORE POST-EMBEDDING IMAGE DATA
S11
OBTAIN PREDICTION VALUE OF PIXEL OF INTEREST
S12
DECODE BY PERFORMING BIT-SWAPPING ACCORDING TO PREDICTION VALUE
S13
STORE
S14
S15
NO
ALL PIXELS FINISHED?
YES
OUTPUT IMAGE DATA AND EMBEDDED DATA
S16
END

FIG. 7

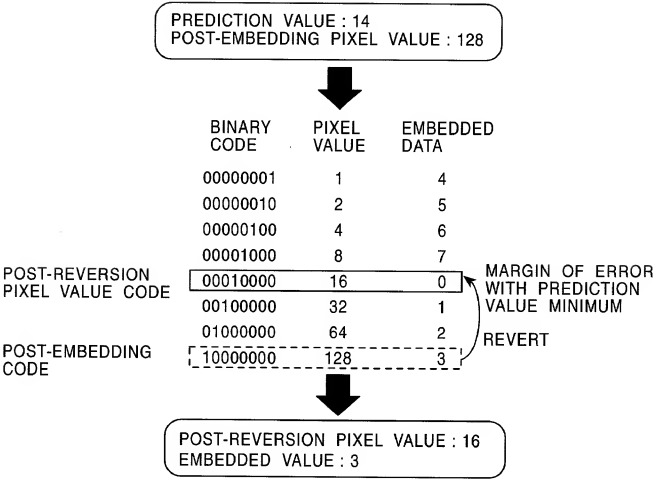

PREDICTION VALUE : 14
POST-EMBEDDING PIXEL VALUE : 128
BINARY CODE
PIXEL VALUE
EMBEDDED DATA
00000001 1 4
00000010 2 5
00000100 4 6
00001000 8 7
POST-REVERSION PIXEL VALUE CODE
00010000 16 0
MARGIN OF ERROR WITH PREDICTION VALUE MINIMUM
00100000 32 1
01000000 64 2
REVERT
POST-EMBEDDING CODE
10000000 128 3
POST-REVERSION PIXEL VALUE : 16
EMBEDDED VALUE : 3

FIG. 8

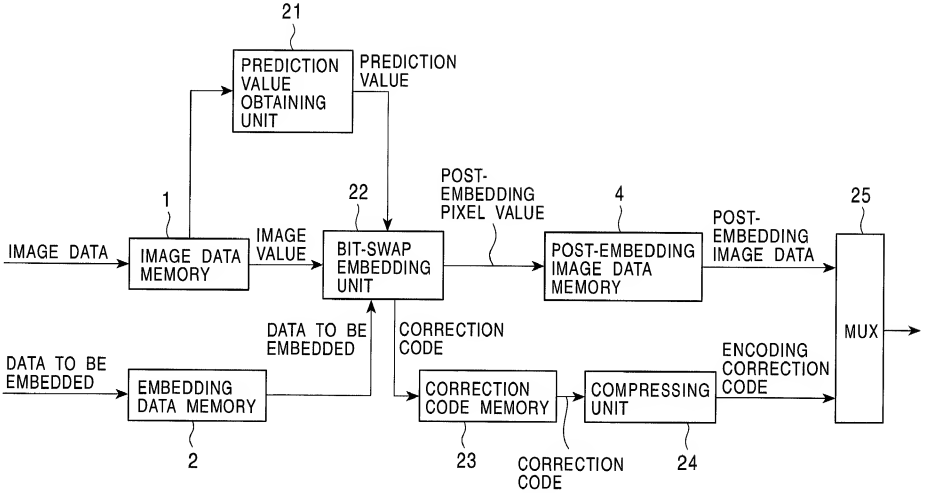

21
PREDICTION VALUE OBTAINING UNIT
PREDICTION VALUE
1
22
POST-EMBEDDING PIXEL VALUE
4
25
IMAGE DATA
IMAGE DATA MEMORY
IMAGE VALUE
BIT-SWAP EMBEDDING UNIT
POST-EMBEDDING IMAGE DATA MEMORY
POST-EMBEDDING IMAGE DATA
MUX
DATA TO BE EMBEDDED
CORRECTION CODE
DATA TO BE EMBEDDED
EMBEDDING DATA MEMORY
CORRECTION CODE MEMORY
COMPRESSING UNIT
ENCODING CORRECTION CODE
2
23
CORRECTION CODE
24

FIG. 9

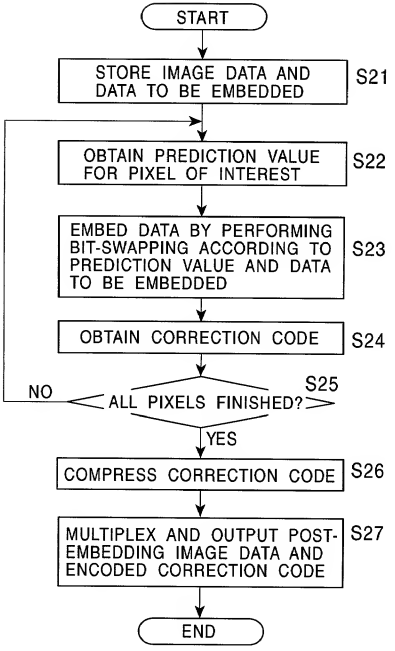

START
STORE IMAGE DATA AND DATA TO BE EMBEDDED
S21
OBTAIN PREDICTION VALUE FOR PIXEL OF INTEREST
S22
EMBED DATA BY PERFORMING BIT-SWAPPING ACCORDING TO PREDICTION VALUE AND DATA TO BE EMBEDDED
S23
OBTAIN CORRECTION CODE
S24
S25
NO
ALL PIXELS FINISHED?
YES
COMPRESS CORRECTION CODE
S26
MULTIPLEX AND OUTPUT POST-EMBEDDING IMAGE DATA AND ENCODED CORRECTION CODE
S27
END

FIG. 10

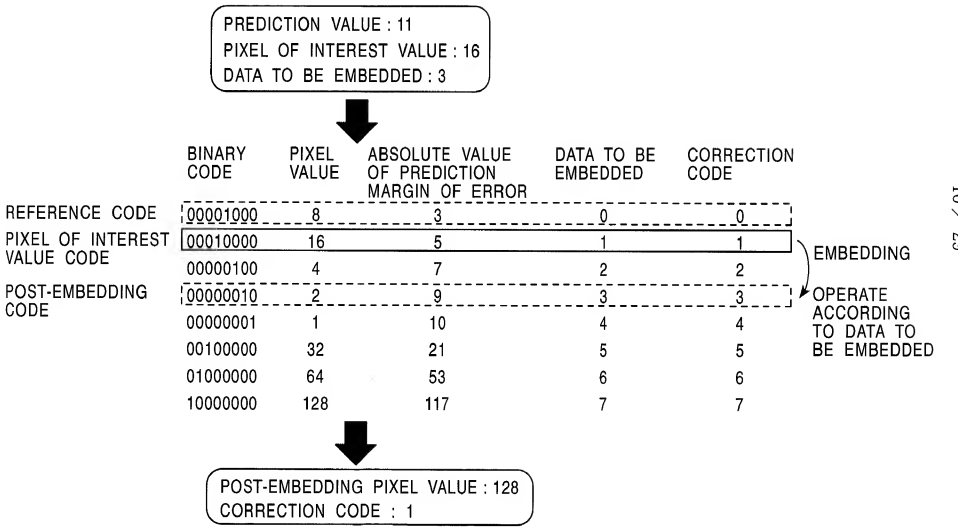

PREDICTION VALUE : 11
PIXEL OF INTEREST VALUE : 16
DATA TO BE EMBEDDED : 3
BINARY CODE
PIXEL VALUE
ABSOLUTE VALUE OF PREDICTION MARGIN OF ERROR
DATA TO BE EMBEDDED
CORRECTION CODE
REFERENCE CODE
PIXEL OF INTEREST VALUE CODE
POST-EMBEDDING CODE
00001000 8 3 0 0
00010000 16 5 1 1
00000100 4 7 2 2
00000010 2 9 3 3
00000001 1 10 4 4
00100000 32 21 5 5
01000000 64 53 6 6
10000000 128 117 7 7
EMBEDDING
OPERATE ACCORDING TO DATA TO BE EMBEDDED
POST-EMBEDDING PIXEL VALUE : 128
CORRECTION CODE : 1

FIG. 11

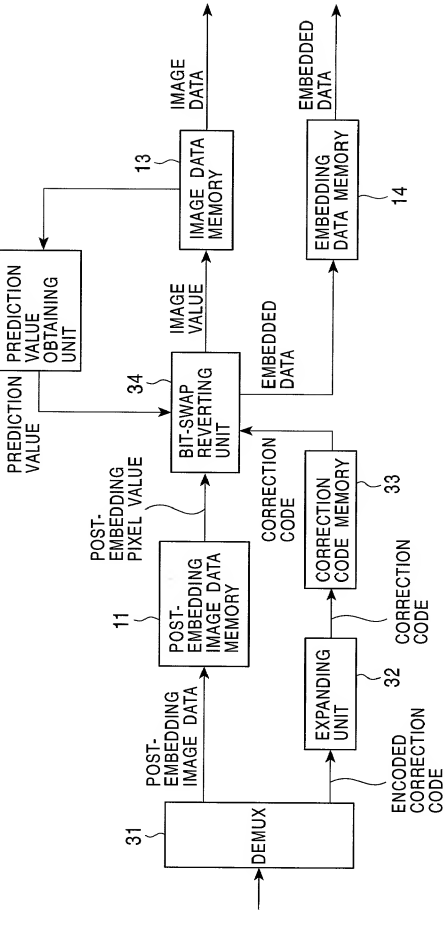

DEMUX
31
POST-EMBEDDING IMAGE DATA
ENCODED CORRECTION CODE
EXPANDING UNIT
32
CORRECTION CODE
CORRECTION CODE MEMORY
33
CORRECTION CODE
POST-EMBEDDING IMAGE DATA MEMORY
11
POST-EMBEDDING PIXEL VALUE
BIT-SWAP REVERTING UNIT
34
IMAGE VALUE
IMAGE DATA MEMORY
13
IMAGE DATA
EMBEDDED DATA
EMBEDDING DATA MEMORY
14
EMBEDDED DATA
PREDICTION VALUE
PREDICTION VALUE OBTAINING UNIT
15
PREDICTION VALUE

FIG. 12

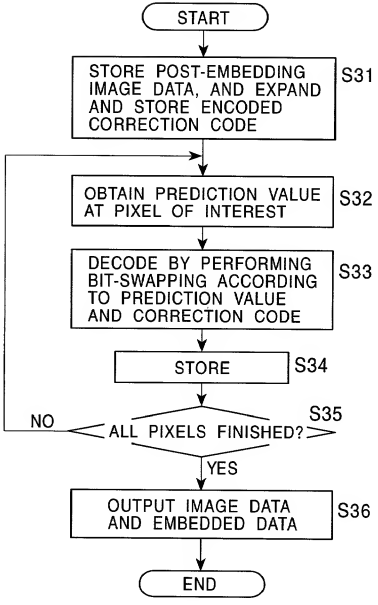

START
STORE POST-EMBEDDING IMAGE DATA, AND EXPAND AND STORE ENCODED CORRECTION CODE
S31
OBTAIN PREDICTION VALUE AT PIXEL OF INTEREST
S32
DECODE BY PERFORMING BIT-SWAPPING ACCORDING TO PREDICTION VALUE AND CORRECTION CODE
S33
STORE
S34
ALL PIXELS FINISHED?
S35
NO
YES
OUTPUT IMAGE DATA AND EMBEDDED DATA
S36
END

FIG. 13

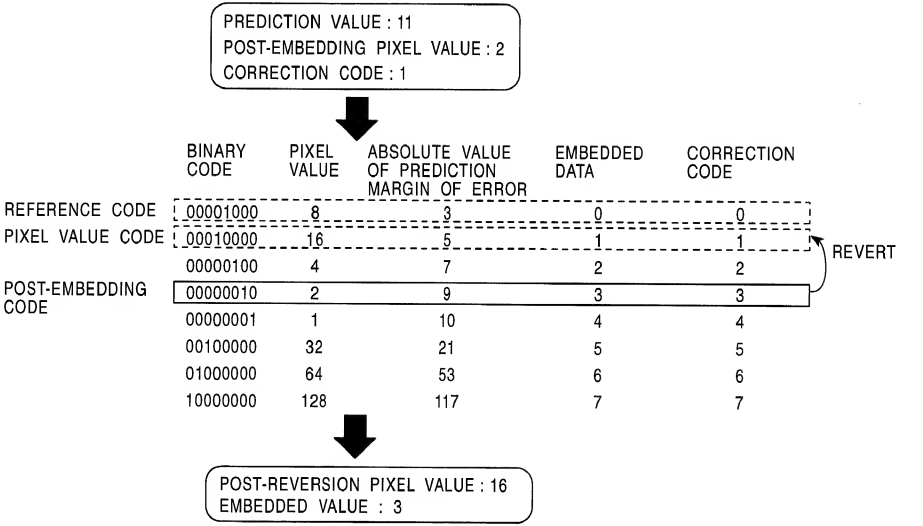

PREDICTION VALUE : 11
POST-EMBEDDING PIXEL VALUE : 2
CORRECTION CODE : 1
BINARY CODE
PIXEL VALUE
ABSOLUTE VALUE OF PREDICTION MARGIN OF ERROR
EMBEDDED DATA
CORRECTION CODE
REFERENCE CODE
00001000 8 3 0 0
PIXEL VALUE CODE
00010000 16 5 1 1
REVERT
00000100 4 7 2 2
POST-EMBEDDING CODE
00000010 2 9 3 3
00000001 1 10 4 4
00100000 32 21 5 5
01000000 64 53 6 6
10000000 128 117 7 7
POST-REVERSION PIXEL VALUE : 16
EMBEDDED VALUE : 3

FIG. 14A

CONVENTIONAL CODE	PIXEL VALUE CORRESPONDING TO CONVENTIONAL CODE
00000001	1
00000010	2
00000100	4
00001000	8
00010000	16 (PIXEL OF INTEREST)
00100000	32
01000000	64
10000000	128

FIG. 14B

CONVENTIONAL CODE	PIXEL VALUE CORRESPONDING TO CONVENTIONAL CODE	MARGIN OF ERROR (ABSOLUTE VALUE)	CORRECTION CODE
00010000	16 (PIXEL OF INTEREST)	1	0
00001000	8	9	1
00000100	4	13	2
00000010	5	15	3
00100000	32	15	4
00000001	1	16	5
01000000	64	44	6
10000000	128	111	7

FIG. 14C

CONVENTIONAL CODE	PIXEL VALUE CORRESPONDING TO CONVENTIONAL CODE	MARGIN OF ERROR (ABSOLUTE VALUE)	CORRECTION CODE
00001000	8	0	0
00000100	4	4	1
00000010	2	6	2
00000001	1	7	3
00010000	16 (PIXEL OF INTEREST)	8	4
00100000	32	24	5
01000000	64	56	6
10000000	128	120	7

FIG. 15

CODE	OLD	NEW	CODE	OLD	NEW	CODE	OLD	NEW	CODE	OLD	NEW
00001111	15	0	01110010	114	116	11011000	216	233	01010001	81	118
00010111	23	3	01110100	116	120	11100001	225	236	01010010	82	122
00011011	27	7	01111000	120	123	11100010	226	240	01010100	84	128
00011101	29	10	10000111	135	127	11100100	228	244	01011000	88	132
00011110	30	14	10001011	139	131	11101000	232	247	01100001	97	136
00100111	39	18	10001101	141	134	11110000	240	251	01100010	98	141
00101011	43	21	10001110	142	138	00000111	7	1	01100100	100	146
00101101	45	25	10010011	147	142	00001011	11	4	01101000	104	150
00101110	46	29	10010101	149	145	00001101	13	9	01110000	112	154
00110011	51	32	10010110	150	149	00001110	14	13	10000011	131	159
00110101	53	36	10011001	153	153	00010011	19	19	10000101	133	164
00110110	54	40	10011010	154	156	00010101	21	22	10000110	134	168
00111001	57	43	10011100	156	160	00010110	22	27	10001001	137	173
00111010	58	47	10100011	163	163	00011001	25	31	10001010	138	177
00111100	60	51	10100101	165	167	00011010	26	37	10001100	140	183
01000111	71	54	10100110	166	171	00011100	28	41	10010001	145	186
01001011	75	58	10101001	169	174	00100011	35	45	10010010	146	191
01001101	77	61	10101010	170	178	00100101	37	50	10010100	148	195
01001110	78	65	10101100	172	182	00100110	38	55	10011000	152	201
01010011	83	69	10110001	177	185	00101001	41	59	10100001	161	205
01010101	85	72	10110010	178	189	00101010	42	63	10100010	162	209
01010110	86	76	10110100	180	193	00101100	44	68	10100100	164	215
01011001	89	80	10111000	184	196	00110001	49	73	10101000	168	219
01011010	90	83	11000011	195	200	00110010	50	77	10110000	176	223
01011100	92	87	11000101	197	204	00110100	52	81	11000001	193	227
01100011	99	91	11000110	198	207	00111000	56	86	11000010	194	232
01100101	101	94	11001001	201	211	01000011	67	92	11000100	196	237
01100110	102	98	11001010	202	214	01000101	69	95	11001000	200	241
01101001	105	102	11001100	204	218	01000110	70	100	11010000	208	245
01101010	106	105	11010001	209	222	01001001	73	104	11100000	224	250
01101100	108	109	11010010	210	225	01001010	74	110	00011111	31	2
01110001	113	112	11010100	212	229	01001100	76	113	00101111	47	5

FIG. 16

CODE	OLD	NEW	CODE	OLD	NEW	CODE	OLD	NEW	CODE	OLD	NEW
00110111	55	11	10111010	186	155	00100001	33	97	11010111	216	135
00111011	59	15	10111100	188	161	00100010	34	103	11011011	219	140
00111101	61	20	11000111	199	165	00100100	36	115	11011101	221	152
00111110	62	23	11001011	203	169	00101000	40	121	11011110	222	158
01001111	79	28	11001101	205	175	00110000	48	130	11011111	231	170
01010111	87	33	11001110	206	179	01000001	65	139	11101011	235	180
01011011	91	38	11010011	211	184	01000010	66	148	11101101	237	190
01011101	93	42	11010101	213	187	01000100	68	157	11101110	238	198
01011110	94	46	11010110	214	192	01001000	72	166	11110011	243	208
01100111	103	52	11011001	217	197	01010000	80	176	11110101	245	213
01101011	107	56	11011010	218	202	01100000	96	188	11110110	246	226
01101101	109	60	11011100	220	206	10000001	129	194	11111001	249	231
01101110	110	64	11100011	227	210	10000010	130	203	11111010	250	243
01110011	115	70	11100101	229	216	10000100	132	212	11111100	252	249
01110101	117	74	11100110	230	220	10001000	136	221	00000001	1	17
01110110	118	78	11101001	233	224	10010000	144	230	00000010	2	35
01111001	121	82	11101010	234	228	10100000	160	239	00000100	4	71
01111010	122	88	11101100	236	234	11000000	192	248	00001000	8	108
01111100	124	93	11110001	241	238	00111111	63	8	00010000	16	144
10001111	143	96	11110010	242	242	01011111	95	16	00100000	32	162
10010111	151	101	11110100	244	246	01101111	111	26	01000000	64	199
10011011	155	106	11111000	248	252	01110111	119	34	10000000	128	235
10011101	157	111	00000011	3	8	01111011	123	44	01111111	127	53
10011110	158	114	00000101	5	12	01111101	125	49	10111111	191	89
10100111	167	119	00000110	6	24	01111110	126	62	11011111	223	90
10101011	171	124	00001001	9	30	10011111	159	67	11101111	239	126
10101101	173	129	00001010	10	39	10101111	175	79	11110111	247	172
10101110	174	133	00001100	12	48	10110111	183	85	11111011	251	181
10110011	179	137	00010001	17	57	10111011	187	99	11111101	253	217
10110101	181	143	00010010	18	66	10111101	189	107	11111110	254	253
10110110	182	147	00010100	20	75	10111110	190	117	0000000	0	254
10111001	185	151	00011000	24	84	11001111	207	125	11111111	255	255

FIG. 17

NEW CODE	PIXEL VALUE CORRESPONDING TO NEW CODE
00111111	8
01011111	16 (PIXEL OF INTEREST)
01101111	26
01110111	34
01111011	44
01111101	49
01111110	62
10011111	67
10101111	79
10110111	85
10111011	99
10111101	107
10111110	117
11001111	125
11010111	135
11011011	140
11011101	152
11011110	158
11100111	170
11101011	180
11101101	190
11101110	198
11110011	208
11110101	213
11110110	226
11111001	231
11111010	243
11111100	249

FIG. 18

NEW CODE	PIXEL VALUE CORRESPONDING TO NEW CODE	MARGIN OF ERROR (ABSOLUTE VALUE)	CORRECTION CODE
01011111	16 (PIXEL OF INTEREST)	1	0
00111111	8	9	1
01101111	26	9	2
01110111	34	17	3
01111011	44	27	4
01111101	49	32	5
01111110	62	45	6
10011111	67	50	7
10101111	79	62	8
10110111	85	68	9
10111011	99	82	10
10111101	107	92	11
10111110	117	100	12
11001111	125	108	13
11010111	135	118	14
11011011	140	123	15
11011101	152	135	16
11011110	158	141	17
11100111	170	153	18
11101011	180	163	19
11101101	190	173	20
11101110	198	181	21
11110011	208	191	22
11110101	213	186	23
11110110	226	209	24
11111001	231	214	25
11111010	243	226	26
11111100	249	232	27

FIG. 19

NEW CODE	PIXEL VALUE CORRESPONDING TO NEW CODE	MARGIN OF ERROR (ABSOLUTE VALUE)	CORRECTION CODE
00111111	8	0	0
01011111	16 (PIXEL OF INTEREST)	8	1
01101111	26	18	2
01110111	34	26	3
01111011	44	36	4
01111101	49	41	5
01111110	62	54	6
10011111	67	59	7
10101111	79	71	8
10110111	85	77	9
10111011	99	91	10
10111101	107	99	11
10111110	117	109	12
11001111	125	117	13
11010111	135	127	14
11011011	140	132	15
11011101	152	144	16
11011110	158	150	17
11100111	170	162	18
11101011	180	172	19
11101101	190	182	20
11101110	198	190	21
11110011	208	200	22
11110101	213	205	23
11110110	226	218	24
11111001	231	223	25
11111010	243	235	26
11111100	249	241	27

FIG. 20

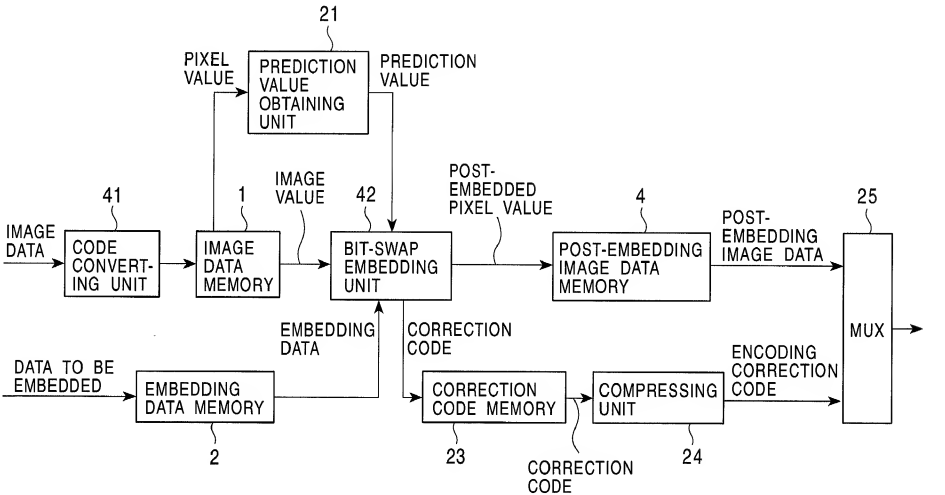

21
PIXEL VALUE
PREDICTION VALUE OBTAINING UNIT
PREDICTION VALUE
41
1
IMAGE VALUE
42
POST-EMBEDDED PIXEL VALUE
4
25
IMAGE DATA
CODE CONVERT-ING UNIT
IMAGE DATA MEMORY
BIT-SWAP EMBEDDING UNIT
POST-EMBEDDING IMAGE DATA MEMORY
POST-EMBEDDING IMAGE DATA
MUX
EMBEDDING DATA
CORRECTION CODE
ENCODING CORRECTION CODE
DATA TO BE EMBEDDED
EMBEDDING DATA MEMORY
CORRECTION CODE MEMORY
COMPRESSING UNIT
2
23
CORRECTION CODE
24

FIG. 21

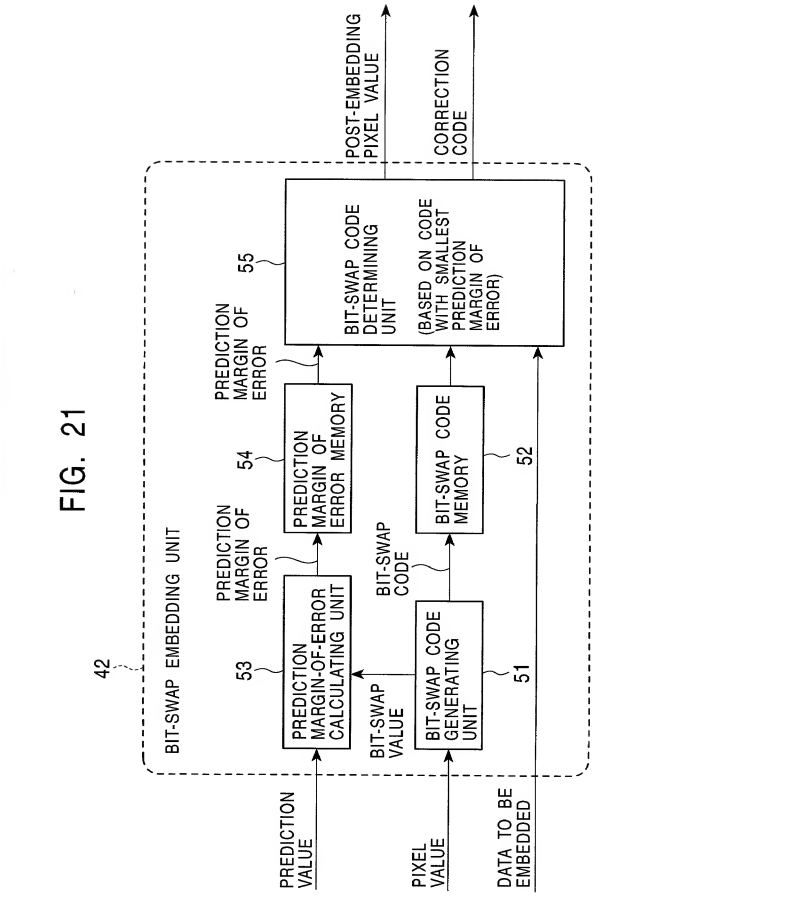

42
BIT-SWAP EMBEDDING UNIT
PREDICTION VALUE
PIXEL VALUE
DATA TO BE EMBEDDED
PREDICTION MARGIN-OF-ERROR CALCULATING UNIT
53
BIT-SWAP CODE GENERATING UNIT
51
PREDICTION MARGIN OF ERROR
BIT-SWAP VALUE
BIT-SWAP CODE
PREDICTION MARGIN OF ERROR MEMORY
54
BIT-SWAP CODE MEMORY
52
PREDICTION MARGIN OF ERROR
BIT-SWAP CODE DETERMINING UNIT
55
(BASED ON CODE WITH SMALLEST PREDICTION MARGIN OF ERROR)
POST-EMBEDDING PIXEL VALUE
CORRECTION CODE

FIG. 22

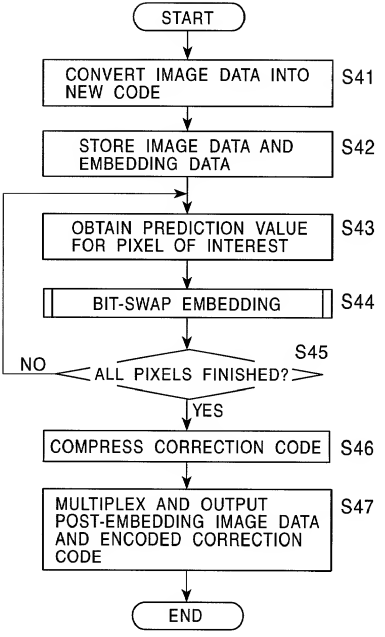

START
CONVERT IMAGE DATA INTO NEW CODE
S41
STORE IMAGE DATA AND EMBEDDING DATA
S42
OBTAIN PREDICTION VALUE FOR PIXEL OF INTEREST
S43
BIT-SWAP EMBEDDING
S44
S45
NO
ALL PIXELS FINISHED?
YES
COMPRESS CORRECTION CODE
S46
MULTIPLEX AND OUTPUT POST-EMBEDDING IMAGE DATA AND ENCODED CORRECTION CODE
S47
END

FIG. 23

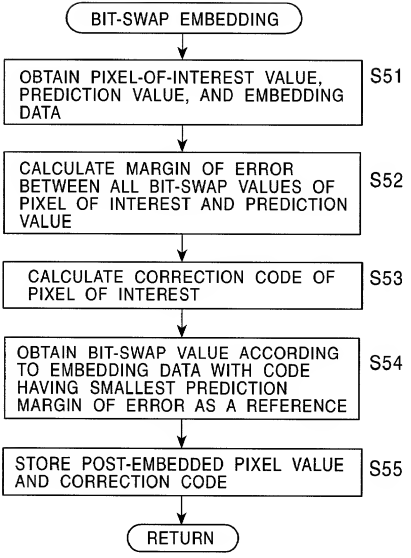

BIT-SWAP EMBEDDING
OBTAIN PIXEL-OF-INTEREST VALUE, PREDICTION VALUE, AND EMBEDDING DATA
S51
CALCULATE MARGIN OF ERROR BETWEEN ALL BIT-SWAP VALUES OF PIXEL OF INTEREST AND PREDICTION VALUE
S52
CALCULATE CORRECTION CODE OF PIXEL OF INTEREST
S53
OBTAIN BIT-SWAP VALUE ACCORDING TO EMBEDDING DATA WITH CODE HAVING SMALLEST PREDICTION MARGIN OF ERROR AS A REFERENCE
S54
STORE POST-EMBEDDED PIXEL VALUE AND CORRECTION CODE
S55
RETURN

FIG. 24

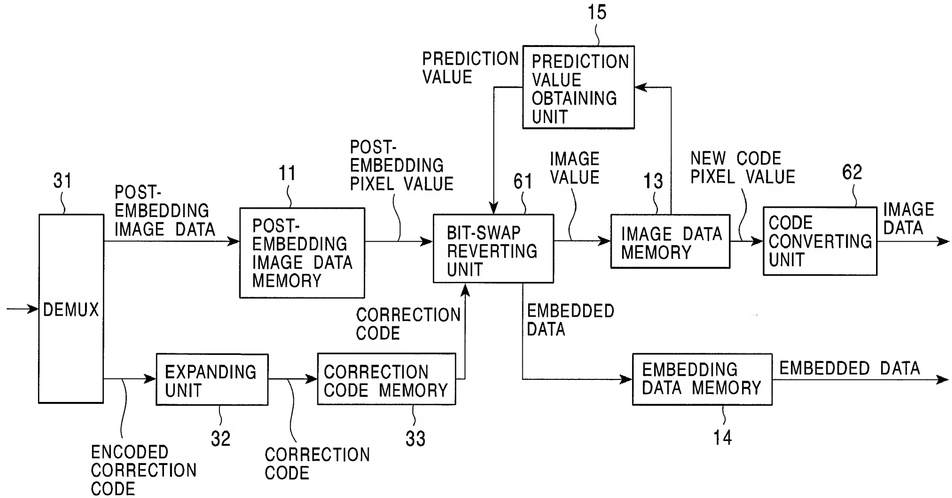

DEMUX
31
POST-EMBEDDING IMAGE DATA
11
POST-EMBEDDING IMAGE DATA MEMORY
POST-EMBEDDING PIXEL VALUE
61
BIT-SWAP REVERTING UNIT
PREDICTION VALUE
15
PREDICTION VALUE OBTAINING UNIT
IMAGE VALUE
13
IMAGE DATA MEMORY
NEW CODE PIXEL VALUE
62
CODE CONVERTING UNIT
IMAGE DATA
ENCODED CORRECTION CODE
EXPANDING UNIT
32
CORRECTION CODE
CORRECTION CODE MEMORY
33
CORRECTION CODE
EMBEDDED DATA
EMBEDDING DATA MEMORY
14
EMBEDDED DATA

FIG. 25

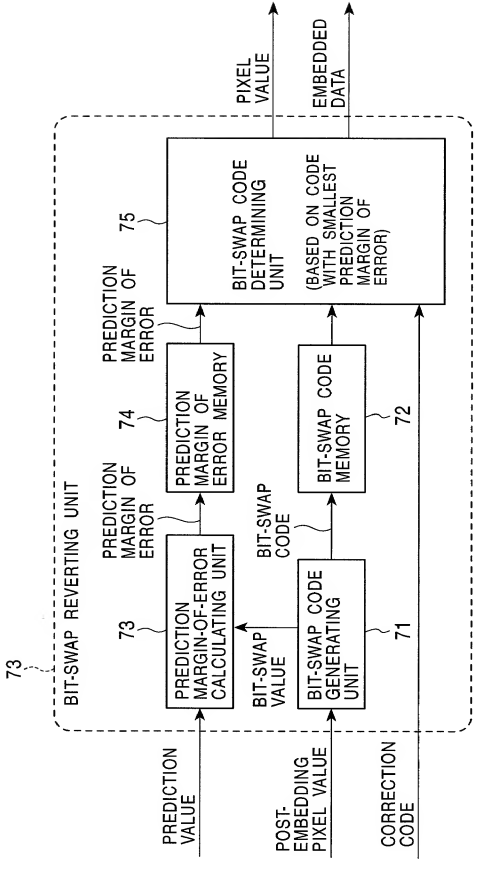

73
BIT-SWAP REVERTING UNIT
PREDICTION VALUE
POST-EMBEDDING PIXEL VALUE
CORRECTION CODE
PREDICTION MARGIN-OF-ERROR CALCULATING UNIT
73
BIT-SWAP CODE GENERATING UNIT
71
BIT-SWAP VALUE
PREDICTION MARGIN OF ERROR
BIT-SWAP CODE
PREDICTION MARGIN OF ERROR MEMORY
74
BIT-SWAP CODE MEMORY
72
PREDICTION MARGIN OF ERROR
BIT-SWAP CODE DETERMINING UNIT
75
(BASED ON CODE WITH SMALLEST PREDICTION MARGIN OF ERROR)
PIXEL VALUE
EMBEDDED DATA

FIG. 26

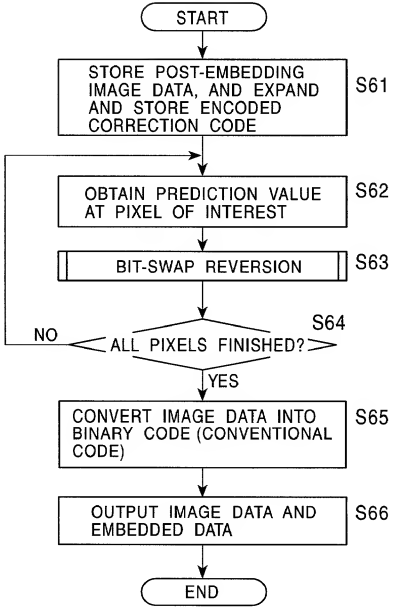

START
STORE POST-EMBEDDING IMAGE DATA, AND EXPAND AND STORE ENCODED CORRECTION CODE
S61
OBTAIN PREDICTION VALUE AT PIXEL OF INTEREST
S62
BIT-SWAP REVERSION
S63
S64
NO
ALL PIXELS FINISHED?
YES
CONVERT IMAGE DATA INTO BINARY CODE (CONVENTIONAL CODE)
S65
OUTPUT IMAGE DATA AND EMBEDDED DATA
S66
END

FIG. 27

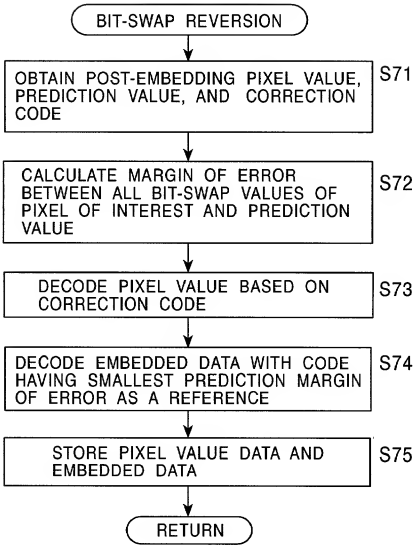

BIT-SWAP REVERSION
OBTAIN POST-EMBEDDING PIXEL VALUE, PREDICTION VALUE, AND CORRECTION CODE
S71
CALCULATE MARGIN OF ERROR BETWEEN ALL BIT-SWAP VALUES OF PIXEL OF INTEREST AND PREDICTION VALUE
S72
DECODE PIXEL VALUE BASED ON CORRECTION CODE
S73
DECODE EMBEDDED DATA WITH CODE HAVING SMALLEST PREDICTION MARGIN OF ERROR AS A REFERENCE
S74
STORE PIXEL VALUE DATA AND EMBEDDED DATA
S75
RETURN

FIG. 28A

IMAGE A

	AMOUNT OF INFORMATION THAT CAN BE EMBEDDED [bit/pixel]	AMOUNT OF CORRECTION CODE DATA [bit/pixel]	DIFFERENCE [bit/pixel]
R	4.94	3.43	1.51
G	5.09	3.57	1.52
B	5.06	3.73	1.33

IMAGE B

	AMOUNT OF INFORMATION THAT CAN BE EMBEDDED [bit/pixel]	AMOUNT OF CORRECTION CODE DATA [bit/pixel]	DIFFERENCE [bit/pixel]
R	4.70	2.53	2.18
G	5.06	2.68	2.38
B	5.03	2.61	2.41

FIG. 28B

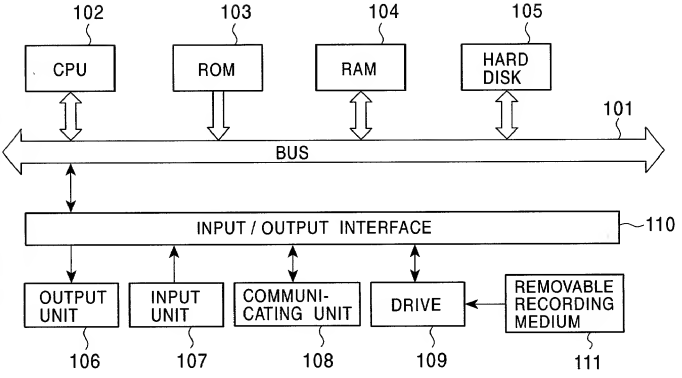
IMAGE A

	AMOUNT OF INFORMATION THAT CAN BE EMBEDDED [bit/pixel]	AMOUNT OF CORRECTION CODE DATA [bit/pixel]	DIFFERENCE [bit/pixel]
R	4.93	2.99	1.94
G	4.93	3.16	1.76
B	4.93	3.38	1.55

IMAGE B

	AMOUNT OF INFORMATION THAT CAN BE EMBEDDED [bit/pixel]	AMOUNT OF CORRECTION CODE DATA [bit/pixel]	DIFFERENCE [bit/pixel]
R	4.89	2.00	2.89
G	4.93	2.16	2.77
B	4.93	2.10	2.83

FIG. 29


102
103
104
105
CPU
ROM
RAM
HARD DISK
101
BUS
INPUT / OUTPUT INTERFACE
110
OUTPUT UNIT
INPUT UNIT
COMMUNI-CATING UNIT
DRIVE
REMOVABLE RECORDING MEDIUM
106
107
108
109
111